Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2017; 6(6): 2381-2384
Received: 29-09-2017
Accepted: 30-10-2017

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# Response of various mycorrhizal strains on tomato (*Solanum lycopersicum* L.) cv. Arka Vikas in relation to growth, yield, and quality attributes

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**Abstract**
An investigation was carried out to study the effect of various mycorrhizal products on growth, yield, and quality parameters of tomato (*Solanum lycopersicum* L.) cv. Arka Vikas. The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi during *Rabi* season of 2016-17. From the analysis, it is clear that $T_2$ - Soil application with Myc100 @ 250 g/ha has proven to be best with respect to most of the characters viz., number of nodes per plant (23.57), root length (49.47 cm), number of fruits per plant (31.00), fruit length (5.69 cm), average fruit weight (91.95 g), fruit yield per plant (2696.27 g), fruit yield/plot (67.41 kg), fruit yield (748.96 q/ha), and TSS (4.86 ºBrix) whereas $T_7$ - Foliar application with Ratchet @ 300 mL/ha × 2 applications at 30 and 60 DAT got highest value (132.17) concerning the plant height (cm) and for the traits like Internodal length (6.76 cm), days to 50% flowering (33.33), and flower drop (33.31%), $T_1$ - Untreated Control has obtained the highest value. From the investigation, it can be concluded that the best product in relation to the growth, yield, and quality parameters was $T_2$ - Soil application with Myc100 and the optimum concentration for its application is 250 g/ha.

**Keywords:** vesicular arbuscular mycorrhizae, *Solanum lycopersicum* L., growth, yield, quality

## Introduction
Among the vegetable crops, tomato stands as the second most important vegetable in the globe after potato (Dorais *et al.*, 2008) [10]. *Solanum lycopersicum* L., the cultivated tomato, belongs to the diverse family solanaceae, which includes more than 3000 species, occupying a wide variety of habitats (Knapp, 2002) [15]. South American Andes is considered as the centre of origin of tomato. The probable progenitor of cultivated tomato is *Lycopersicon esculentum* var. *cerasiforme,* popularly called as cherry tomato. The total area and production of tomato is 7,67,000 ha and 1,63,85,000 MT, respectively with productivity of 21.36 MT/ha and the major leading states in tomato production are Uttar Pradesh, Maharashtra, and West Bengal (Anonymous, 2015) [3]. Tomato is one of the significant crops in the world which have got known benefits from a symbiotic relationship with mycorrhizae (Nzanza *et al*., 2011) [19]. In the functioning of the low input environments, mycorrhiza plays an essential ecological position. AM fungi having particular biological features, are the microbial partners of this symbiosis, being multinucleated obligate biotrophs. Due to the complex molecular dialogue with their host plants, colonization of the plant root cortex occurs and there is development of intercellular hyphae and highly branched structures known as arbuscules within the cells (Bonfante and Requena, 2011) [6]. The fungus obtains carbohydrates (sugars) and additional growth factors from the plant, which in turn gets numerous benefits, including improved nutrient absorption, mainly phosphorus and nitrogen, which are taken up from the bulk soil by its mycelium and transferred through the symbiotic interface to the plant root cells (Javot, 2007) [14]. In turn, the plant supplies the fungus with about 10-20 per cent of its net photosynthates.
Keeping in view the above facts, the effects of various mycorrhizal strains on growth, productivity, and quality aspects of tomato has been investigated in the following study.

## Materials and Methods
The experiment was undertaken at the Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Rabi* season of 2016-17. Each line was replicated thrice with a spacing of 60 cm × 60 cm in between plant to plant and row to row. The experimental design followed was Randomized Complete Block

Design (RCBD). All the recommended package of practices was followed to raise a good crop. The cultivar Arka Vikas was included in the study considering nine treatments viz., $T_1$ - Untreated Control, $T_2$ - Myc100 @ 250 g/ha × Single application at 20 DAT, $T_3$ - RhizoMyco100 @ 250 g/ha × Single application at 20 DAT, T4 - RhizoMyxo100 @ 250 g/ ha × Single application at 20 DAT, $T_5$ - Bolt Gr. @ 10 kg/ha × Single application at 20 DAT, $T_6$ - Ratchet @ 300 mL/ha × Single application at 30 DAT, $T_7$ - Ratchet @ 300 mL/ha × Double application at 30 and 60 DAT, $T_8$ - Ratchet @ 450 mL/ha × Single application at 30 DAT, $T_9$ - Ratchet @ 450 mL/ha × Double application at 30 and 60 DAT. Observations were recorded from five randomly selected plants excluding the border ones and the data was subjected to statistical analysis. The 15 observations included in the study are plant height (cm), number of primary branches per plant, number of nodes per plant, internodal length (cm), days to 50% flowering, root length (cm), flower drop (%), number of fruits per plant, fruit length (cm), fruit diameter (cm), average fruit weight (g), fruit yield per plant (g), fruit yield plot$^{-1}$ (kg), fruit yield (q/ha), and TSS (ºBrix). Mean of various treatments was analyzed statistically by the method outlined by Cochran and Cox, 1957 [9].

**Results and Discussion**

Application of mycorrhiza significantly improves almost all the characters regarding growth, yield, and quality. The mean performance of various mycorrhizal formulations on growth, yield, and quality parameters has been illustrated in Table 1. The analysis of different parameters revealed that the treatment $T_7$ - Foliar application with Ratchet @ 300 mL/ha × 2 applications at 30 and 60 DAT recorded maximum plant height (132.77 cm). The increased plant height may be due to the better nutrient uptake caused by the mycorrhiza which made normally unavailable nutrients available to plants. These results are in conformity with the earlier findings of Edathil *et al.* (1996) [11]; Alfonso and Leyva (2006) [2] and Sajan *et al.* (2002) [21] in tomato. Highest number of primary branches seen under treatment $T_3$ - Soil application with RhizoMyco100 @ 250 g/ha application at 20 DAT (9.47) followed by treatment $T_4$ - Soil application with RhizoMyxo100 @ 250 g/ha × 1 application at 20 DAT (8.60). Treatments $T_3$ and $T_4$ were statistically at par with each other. The increased number of branches as compared to control was might be due to increased absorption of nutrient such as phosphorus, copper, iron, and zinc. These results were in accordance with the previous findings of Chakraborty *et al.* (2008) [8]; Hadad *et al.* (2012) [13]; and Bhuvaneswari *et al.* (2014) [5].

The maximum number of nodes were recorded in treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT with value of 23.57. More number of internodes also related to more bearing of fruit clusters which may resulted in increased yield. This increased number of nodes was due to increased nutrient availability to plants through mycorrhiza. These results are in accordance with finding of Liasu (2008) [16]. The minimum internodal length, which is desirable was found in the treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT (4.95). Minimum number of days to 50% flowering was recorded in treatment $T_5$ - Soil application with Bolt Gr. @ 10 kg/ha × 1 application at 20 DAT and $T_6$ - Foliar application with Ratchet @ 300 mL/ha × 1 application at 30 DAT with value of 30.33 days each. The days to 50% flowering was significantly decreased in treatment $T_5$ and $T_6$ as compared to control. The induction of early flowering was related to better nutritional status of plant due to proper nutrient supply through mycorrhiza from soil particularly phosphorus and zinc absorption increased, which resulted in early induction of flowering. This result was in accordance with the finding of Ortas *et al.* (2013) [20].

Application of mycorrhiza significantly increased the root length after 60 days of transplanting depending on different treatment. The maximum root length was observed in treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT (49.47 cm). The increase in root length was due to greater colonization of mycorrhizal fungus on roots which has resulted in greater accumulation of nutrients as well as photosynthates from the shoot (leaves) of plants. These results were in agreement with the earlier findings of Neumann and George (2005) [18]; and Motha *et al.* (2014) [17] in tomato.

Application of mycorrhiza in tomato plant causes the reduction in flower drop. The minimum flower drop (%) was observed in treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT (20.58). The decrease in the flower drop was due to colonization of mycorrhizal fungus on roots which aid in nutrient uptake from soil such as phosphorus. These results were in agreement with the earlier findings of Jasim *et al.* (2014).

Application of mycorrhizal formulations on tomato plants has resulted in substantial upsurge in the number of fruits per plant. Highest number of fruits (31.00) were observed with treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT. The possible reason behind synergistic impact of mycorrhiza on improvement in number of fruits was the increased phosphorus content in plant which had exerted a positive effect on cell division and energy storage. This result was in conformity with the works of Hadad *et al.* (2012) [13] on tomato as well as Gurumurthy *et al.* (2014) [12] on chilli. The highest fruit length was observed in treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT with the value of 5.69 cm. The use of mycorrhizal products significantly increased the length of fruit. This result is in agreement with the finding of Castillo *et al.* (2013) [7] on the Chilean pepper plants. Various mycorrhizal inoculations have significantly improved the fruit diameter. The maximum fruit diameter i.e., 6.59 cm was observed in $T_6$ - Foliar application with Ratchet @ 300 mL/ha × 1 application at 30 DAT. The results obtained were in accordance with the findings of Banu *et al.* (2013) [4].

The maximum weight (91.95 g) of fruit observed in $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT. The substantial increase in the average fruit weight of tomato by the application of treatments with mycorrhizal products may be due to tissue phosphorus get increased which results in proper formation of nucleic acids and due to cell division. These results are in agreement with the findings of Hadad *et al.* (2012) [13] and Alawathugoda (2014) [1] in tomato and Castillo *et al.* (2013) [7] in Chilean pepper. The maximum fruit yield per plant was recorded for the treatment $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT (2696.27 g). The increased plant yield was due to the accelerated nutrient uptake particularly phosphorus by the plant. This result was in the conformity of the finding of Constantino (2008). This result was also in accordance with the finding of Chakraborty *et al*. (2008) [8].

After the application of mycorrhiza, substantial differences were observed in fruit yield per plant depending on various treatments. The maximum fruit yield per plot was recorded in $T_2$ - Soil application with Myc100 @ 250 g/ha × 1 application at 20 DAT followed by $T_4$ - Soil application with RhizoMyxo100 @ 250 g/ha × 1 application at 20 DAT with a value of 67.41 kg and 64.15 kg, respectively. Due to the upliftment in the absorption of nutrients, the yield per plant in experimental plot hiked which resulted in the increase in the yield per plot. The present findings are in agreement with the work of Al-Saidy and Muslih (2009) in tomato.

**Table 1:** Mean performance of various mycorrhizal formulations on growth, yield, and quality parameters of tomato

| Treatments | Plant height (cm) | Number of primary branches per plant | Number of nodes per plant | Internodal length (cm) | Days to 50% flowering | Root length (cm) | Flower drop (%) | Number of fruits per plant | Fruit length (cm) | Fruit diameter (cm) | Average fruit weight (g) | Fruit yield per plant (g) | Fruit yield/plot (kg) | Fruit yield (q/ha) | TSS (ºBrix) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 112.20 | 6.27 | 15.54 | 6.76 | 33.33 | 36.70 | 33.31 | 25.91 | 5.15 | 6.19 | 85.6 | 1940.27 | 48.51 | 538.96 | 3.61 |
| $T_2$ | 119.20 | 8.20 | 23.57 | 4.95 | 32.00 | 49.47 | 20.58 | 31.00 | 5.69 | 6.58 | 91.95 | 2696.27 | 67.41 | 748.96 | 4.86 |
| $T_3$ | 117.40 | 9.47 | 22.11 | 5.15 | 32.33 | 43.38 | 26.58 | 28.08 | 5.16 | 6.49 | 90.15 | 2339.60 | 58.49 | 649.88 | 3.88 |
| $T_4$ | 122.00 | 8.60 | 20.47 | 5.24 | 32.00 | 47.77 | 21.98 | 30.01 | 5.47 | 6.04 | 89.98 | 2565.87 | 64.15 | 712.74 | 4.33 |
| $T_5$ | 103.07 | 7.53 | 16.40 | 6.19 | 30.33 | 46.30 | 22.69 | 29.19 | 5.60 | 6.39 | 90.96 | 2454.93 | 61.37 | 681.92 | 4.42 |
| $T_6$ | 114.27 | 7.33 | 18.14 | 5.61 | 30.33 | 41.96 | 26.55 | 27.28 | 5.41 | 6.59 | 91.80 | 2321.47 | 58.05 | 645.00 | 3.59 |
| $T_7$ | 132.17 | 7.89 | 20.49 | 5.27 | 31.67 | 40.11 | 28.91 | 27.12 | 5.23 | 6.43 | 85.93 | 2305.10 | 57.63 | 640.30 | 3.69 |
| $T_8$ | 112.20 | 8.33 | 19.07 | 5.50 | 30.67 | 45.00 | 22.92 | 29.57 | 5.39 | 6.23 | 90.25 | 2422.53 | 61.06 | 678.48 | 3.97 |
| $T_9$ | 115.00 | 8.43 | 17.79 | 5.84 | 31.00 | 41.31 | 25.33 | 28.72 | 5.15 | 6.07 | 86.46 | 2375.47 | 59.39 | 659.85 | 4.06 |
| SE(d) | 7.04 | 0.61 | 0.61 | 0.27 | 0.85 | 0.83 | 0.73 | 0.57 | 0.16 | 0.17 | 2.11 | 59.69 | 1.49 | 16.55 | 0.28 |
| CD at 5% | 14.93 | 1.30 | 1.30 | 0.57 | 1.80 | 1.75 | 1.55 | 1.21 | 0.35 | 0.36 | 4.48 | 126.53 | 3.16 | 35.09 | 0.60 |

$T_1$ - Untreated Control, $T_2$ - Myc100 @ 250 g/ha × 1 application at 20 DAT, $T_3$ - RhizoMyco100 @ 250 g/ha × 1 application at 20 DAT, $T_4$ – RhizoMyxo100 @ 250 g/ ha × 1 application at 20 DAT, $T_5$ - Bolt Gr. @ 10 kg/ha × 1 application at 20 DAT, $T_6$ - Ratchet @ 300 mL/ha × 1 application at 30 DAT, $T_7$ - Ratchet @ 300 mL/ha × Double application at 30 and 60 DAT, $T_8$ - Ratchet @ 450 mL/ha × 1 application at 30 DAT, $T_9$ - Ratchet @ 450 mL/ha × Double application at 30 and 60 DAT

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